How are Watersheds Impaired?

Seeing the Pond from the Pipe
Emily Forbes
Kindergarten
Kennesaw, Georgia
Lewis Elementary School

Both natural events and human activities affect watersheds. Natural events such as storms, fires, and droughts can suddenly alter watershed conditions at large scales. While some natural events have negative impacts, these events are often critical for long-term ecological health. For example, a fire may damage a forest, but it also rejuvenates the forest by spreading seeds of key species and adding necessary nutrients to the forest floor. Individual human activities typically have smaller and more predictable impacts, but their cumulative impact can be far greater. Increases in population, land development, and economic activity increase demands for water, waste disposal, and raw materials. These activities increase pollutant releases to water and air and degrade or fragment natural habitats. Without appropriate management, these changes can seriously compromise watershed health.

Assessments of watershed conditions often measure physical, biological, and chemical watershed variables, such as soil stability, plant and animal diversity, and water quality. Assessments can also measure watershed functions such as nutrient cycling, temperature control, and water availability. This section briefly describes the condition of the nation's watersheds in the context of threats to watershed health. The remainder of the report describes the successes and obstacles of watershed approaches that address these threats.

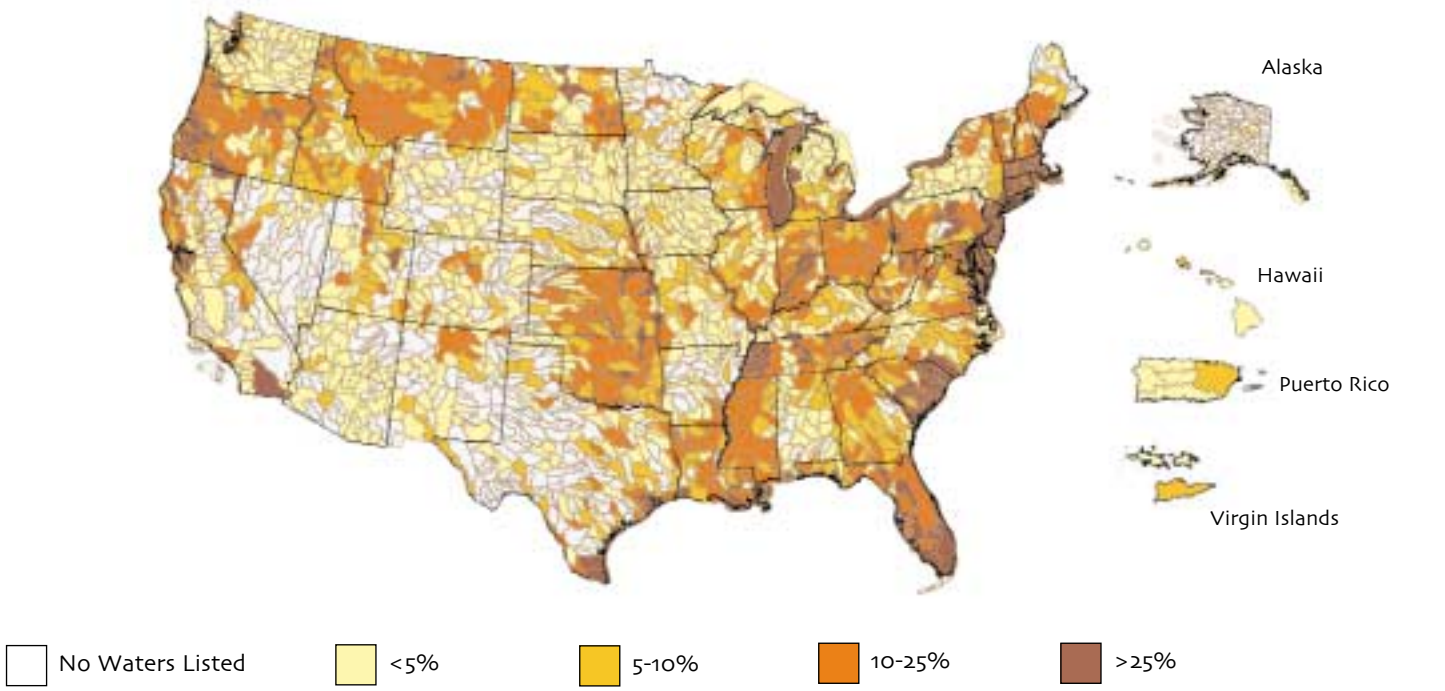
The National View

As required by the Clean Water Act, states, tribes, territories, and interstate commissions develop biennial assessments of streams, lakes, wetlands, and estuaries for a National Water Quality Inventory Report to Congress. In 1998, these parties reported that about 40 percent of their assessed streams, lakes, and estuaries were not clean enough to support uses such as fishing and swimming (see Figure 2).

Although these parties assessed only 23 percent of the nation's streams and rivers in 1998, they reported that more than 291,000 miles of rivers and streams do not fully support aquatic life, fish consumption, swimming, and drinking water uses. Most of the United States' population, more than 218 million people, live within ten miles of an impaired waterbody.

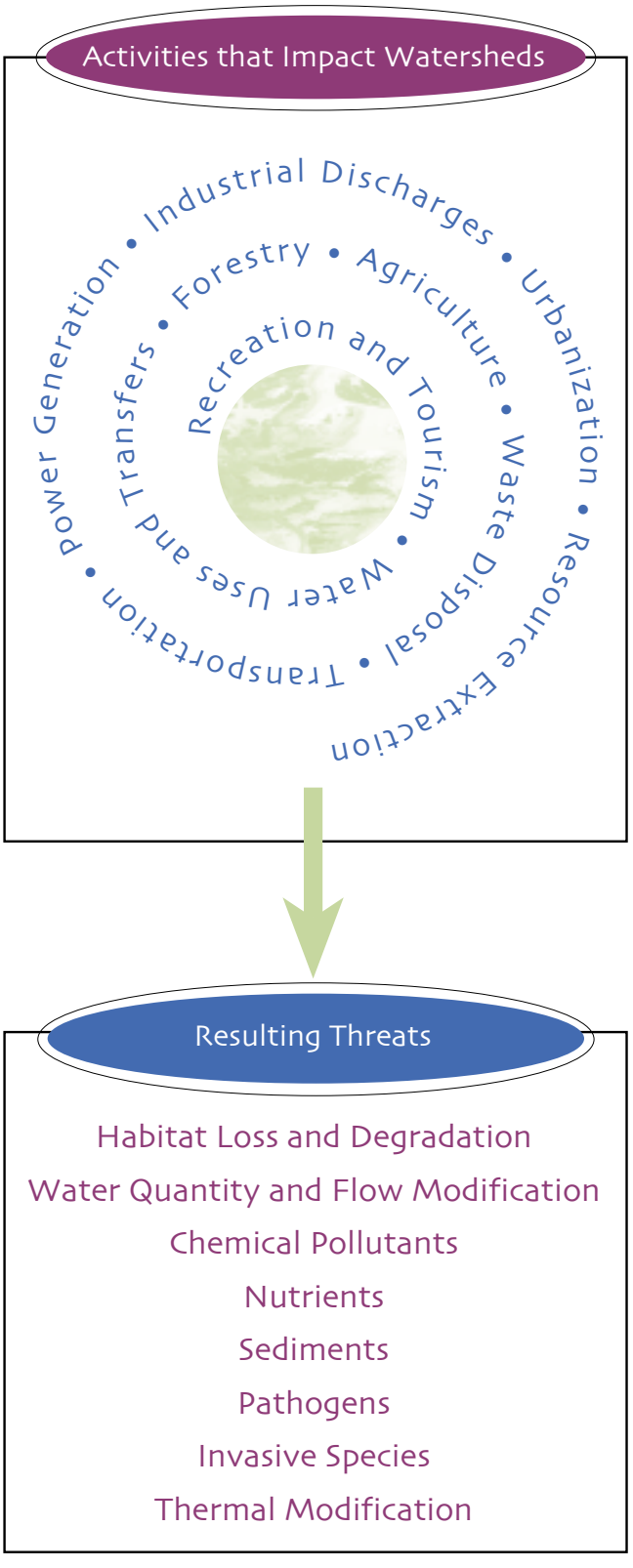
Figure 3 outlines the major activities that impact watersheds and the threats that result. The remainder of this section describes the threats in greater detail. Most watersheds are impacted by more than one activity, and many watersheds are impacted by all activities outlined in Figure 3. Successful watershed approaches address many threats to watershed health with a coordinated and comprehensive strategy.

FIGURE 2. 1998 Impaired Waters–National Summary



The colors in this figure show the percentage of waters threatened within watersheds, divided by the total number of water miles in those watersheds.

FIGURE 3. Threats to Watershed Health



Habitat Loss and Modification

Historically, this nation has not fully appreciated its dependence on healthy ecosystems. From coastal estuaries to mountain forests, human activities such as residential and commercial development, recreation, and resource extraction have changed, fragmented, and destroyed natural habitats.

Habitat loss has severe impacts and can be permanent. For example, coastal wetlands converted to commercial or residential uses provide neither nursery habitat for estuarine fish nor protection from hurricane storm surges. Wetland losses have also contributed to significant declines in waterfowl populations. Forest losses impact many plant and animal species in both aquatic and terrestrial habitats. Forest and wetland losses increase overland flow and reduce filtration of sediments and pollutants, increasing the likelihood that pollutants will reach streams, rivers, and estuaries.

Habitat modification is less obvious, but it is detrimental nonetheless. For example, when communities build roads over streams, they modify the stream habitat. Road culverts prevent fish passage and seriously impact fish populations. Anadromous fish, species that migrate from freshwater to saltwater and back to freshwater, cannot breed successfully if culverts block their migration routes. Anadromous species may have value for recreational and commercial fishermen or they may provide a critical food supply for commercially valuable fish.

Urban streams often provide good examples of habitat modification. When communities straighten and channelize urban streams and line them with concrete, they modify the vegetative and physical structure of the riverine habitat, increase river velocities during rainstorms, and decrease river volumes during dry periods. Straightened and channelized streams also carry more sediments and chemical pollutants to their receiving waters.

The examples of road construction and stream urbanization demonstrate how habitat modification can affect flow

rates, stream ecology, and the characteristics of the waterbody itself. Appropriate engineering techniques and other mitigating measures that consider the natural structure and function of watersheds can reduce these impacts.

Water Quantity & Flow Modification

People, plants, and animals depend on sufficient water flows in rivers and streams. If stream flows are low, fluctuating, or blocked by physical barriers, these changes can affect many plant and animal species. These changes can also affect recreational opportunities. American rivers suffer from these problems because our citizens have devised many methods to capture, control, store, and divert water. These alterations support drinking water supplies, hydropower, irrigation, flood control, manufacturing uses, and recreation.

For example, in the last century the United States has led the world in dam construction to block and harness rivers. Few human actions have more significant impacts on a river system than dam construction. Dams change upstream and downstream habitats, water temperatures, water quality, and sediment movement. They also block or slow the movement of materials and organisms throughout a watershed.

Chemical Pollutants

When chemical compounds are introduced into a watershed, they can compromise drinking water systems, contaminate fish, and degrade water quality. Chemicals reach waterbodies from many sources, including factories, wastewater treatment plants, cars, boats, lawns, and crop fields. For example, insecticide concentrations in urban and suburban waters commonly exceed guidelines for aquatic life protection. Homeowners, commercial properties, and golf courses most commonly apply these insecticides.

Acid mine drainage from abandoned mine lands threatens natural resources, public health, and community vitality. In the nation's coal fields and hard rock mining areas, sulfur-bearing minerals in abandoned mines and refuse piles contaminate adjacent and downstream waters with acidic and metal-laden waters. The contamination often eliminates all aquatic life and compromises drinking waters.

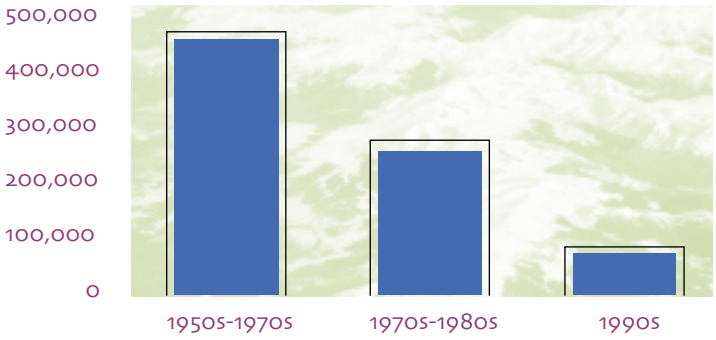
Mercury contamination prevents human consumption of fish in many

If coastal rivers and streams are dammed or otherwise altered by human activities, anadromous fish cannot swim upstream to reproduce.

Wetland Loss Rates

The lower 48 states have lost more than 50 percent of their wetlands (over 100 million acres) since 1780. The U.S. Fish and Wildlife Service recently estimated that the United States still loses over 50,000 acres of wetlands each year. States and tribes most often identify road construction, residential development, and the conversion of lands for agricultural use as the leading reasons for loss. Although the nation is far from its goal of gaining 100,000 acres of wetlands annually, the annual rate of loss has been decreasing in the last five decades as indicated by the adjacent chart.

FIGURE 4. Wetland Acres Lost Annually



Waters downstream of abandoned mines and refuse piles can be contaminated with acids and metals. In this photograph, the orange color of the water dramatically identifies this contamination.

lakes, streams, rivers, and coastal areas. Fish consumption advisories for mercury have more than doubled in number from 1993 to 1998, affecting nearly 2000 waterbodies nationwide. In January 2001, the Food and Drug Administration issued a nationwide advisory recommending pregnant women and women of childbearing age not eat certain kinds of marine fish, including shark, swordfish, and some mackerel due to high levels of methyl mercury found in these species. Coal-burning power plants and urban runoff are significant sources of mercury.

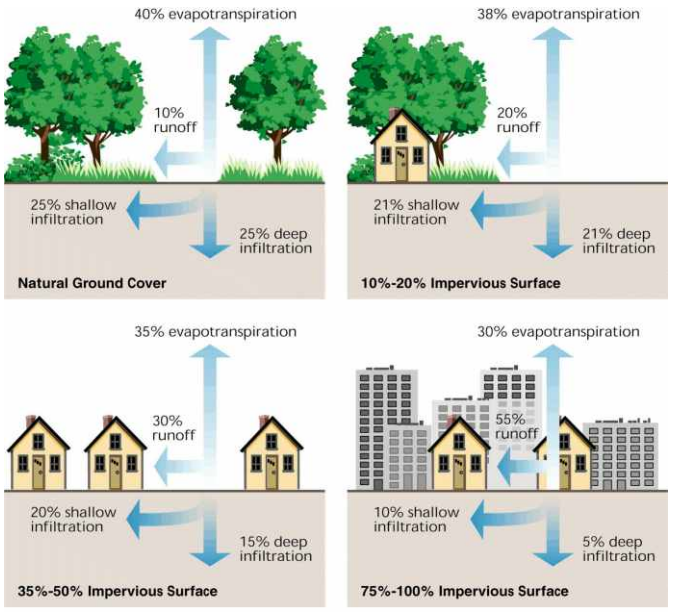
Our nation has effectively managed discrete point sources of chemical pollution, but widespread nonpoint sources of chemical inputs to waterbodies from property owners, resource users, and everyday activities continue to threaten watershed health.

Nutrients

Healthy marine and freshwater environments require the nutrients nitrogen and phosphorus. However, human activities can contribute excessive amounts of these nutrients to a waterbody, causing overwhelming aquatic plant growth. The plant growth consumes large amounts of oxygen and prevents sunlight penetration of the water column. This process, eutrophication, threatens all water organisms. It reduces oxygen, impairs water clarity, and displaces key species. Excessive nutrients can also spur harmful algae blooms that can kill fish and potentially harm people. For example, *Pfiesteria* outbreaks and some red tides can introduce toxins that poison fish and shellfish and threaten the health of humans that come in contact with affected waters.

The U.S. Geological Survey's National Water Quality Assessment indicates that streams and groundwater in agricultural or urban areas almost always contain levels of nitrogen and phosphorus that can cause excessive plant growth. The l998 National Water Quality Inventory lists nutrients as a leading cause of water pollution. States reported that excessive nutrients have degraded more than 3.4 million acres of lakes and reservoirs and 84,000 miles of rivers and streams. The National Oceanic and Atmospheric Administration's National Estuarine Eutrophication Survey found moderate to high eutrophic

FIGURE 5. Impervious cover and Surface Runoff



Impervious surfaces increase surface runoff and accompanying volumes of sediments, nutrients, and chemicals.

conditions in 65 percent of the estuaries in the survey. In agricultural areas, runoff containing fertilizers and manure elevates nutrient levels, while in urban areas nutrients typically come from failing septic systems and the excessive fertilization of suburban lawns, golf courses, and commercial developments. In some estuaries, air deposition of nitrogen contributes a significant portion of the nitrogen found in the water. Nitrogen is released into the air by the combustion of fossil fuels in cars, power plants, and factories, and returns to the watershed in rainwater and air currents.

Excessive nutrients in our coastal waters are a leading cause of hypoxic zones–areas with little or no oxygen. A hypoxic zone in the Gulf of Mexico has eliminated most aquatic life in an area averaging 5,000 square miles during the summers from 1996-2000. In Long Island Sound, another hypoxic area may have killed millions of shellfish in the summer of 2000.

Nutrient contamination can also impact drinking water resources. Excessive nutrient concentrations can cause unpleasant tastes and odors, increase drinking water treatment costs, and violate drinking water standards.

Sediments

Sediments are eroded soils transported by wind and water. Excessive volumes of sediments entering waterbodies can diminish water clarity, alter habitats, impair fish spawning success, and increase drinking water treatment costs. Timber harvesting, mining, agriculture, and construction can introduce excessive sediments if improperly managed. These activities remove vegetation and manipulate soils, allowing wind or water to carry loosened sediments to nearby waterbodies.

Increases in impervious surfaces exacerbate this problem (see Figure 5). Impervious surfaces include buildings, concrete sidewalks, and asphalt driveways and roads. Increases in impervious surfaces decrease infiltration of rainwater into soils and increase surface runoff. Increases in surface runoff increase soil erosion and sediment transport to streams, rivers, lakes, and estuaries.

Forest Land Road Trends

Improperly managed forest land roads can erode and increase sedimentation in watersheds. In 1998, the Forest Service constructed only 215 miles of new roads, one-tenth of the construction in 1988. In addition, the Forest Service has decommissioned 25,000 miles of roads in the past decade.

The Forest Service receives only about 20 percent of the funds necessary to fully maintain Forest Service roads and meet intended safety, service, and environmental standards. As of December 2000, the Forest Service estimates it has a road maintenance and repair backlog of approximately eight billion dollars.

Pathogens

Pathogens are microorganisms that cause disease. Pathogens in freshwater and estuarine environments include both bacteria and viruses. Citizens can be exposed to aquatic pathogens when they drink water, eat fish or shellfish, or come into contact with surface waters during work or recreation. Gastroenteritis, hepatitis, and cholera are examples of diseases associated with waterborne pathogens. The Centers for Disease Control and Prevention estimate that waterborne microbial infections cause up to 940,000 illnesses and 900 deaths each year in the United States.

Potentially harmful bacteria can enter waters from sewage treatment plant discharges, stormwater outflows, boat discharges, malfunctioning septic systems, and runoff from poorly managed animal feeding operations. Once released in the water, pathogens disperse, contaminating the water column, bottom sediments, and aquatic life. Although

Concentrated animal feeding operations are large agricultural enterprises that keep and raise animals in confined situations. Poorly managed concentrated animal feeding operations can threaten watersheds with pathogens, excessive nutrients, and chemical pollutants.

some communities regularly monitor shellfish harvesting areas and bathing beaches, communities cannot detect all pathogen outbreaks before the public is at risk. Enhanced prevention provides the only practical solution.

Invasive Species

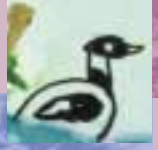
Species are considered invasive if their presence in an ecosystem will cause environmental harm, economic harm, or harm to human health. Invasive species can displace native species, alter predator-prey relationships, destroy crops, and decrease ecosystem resiliency. Invasive species are usually non-native species, and they are often exotic species from another part of the world. Native species can also be characterized as invasive if they dominate their ecosystem due to human induced changes to that ecosystem.

When species are moved outside their normal range into a new region, they can create havoc. Species are unintentionally transported in cargo bays, in ballast waters, and

Invasive Species: How big is the problem?

- Scientists have linked invasive species to 70 percent of this century's extinctions of native aquatic species.
- By one recent estimate, invasive species cost private landowners more than $100 billion per year in treatment costs and lost productivity. This estimate does not consider public costs of wildlife loss, displacement of threatened and endangered species, and reduced opportunities for fishing, hunting, camping, and other recreation.
- Invasive species control has been considered one of the top priorities of the U.S. Fish and Wildlife Service since 1999.
- Five hundred scientists recently asked political leaders to make aquatic nuisance species control a priority issue.

Zebra mussels introduced from Europe have invaded the waters of 20 states in the U.S. since 1988. They have overwhelmed pipes used for municipal and industrial water supply, and studies suggest that their invasion may severely impact native mussel populations.



on the clothes of tourists, or they are intentionally imported and exported for landscaping, aesthetics, animal control, and recreation. Not all non-native species become pests in new locations, but the gypsy moth, nutria, zebra mussel, hydrilla, sea lamprey, and kudzu are examples of non-native invasive species that have caused massive economic and ecological losses. When their new ecosystem lacked the natural controls of their native ecosystems, these invasive species overran millions of acres of rangelands, forestlands, riparian areas, and waterbodies.

Thermal Modification

Many activities can cause thermal modification, or temperature change. Industrial sites or power generation plants often discharge warm water. The removal of streambank or aquatic vegetative cover reduces shade and increases stream temperatures. Dams may increase or decrease water temperatures depending on their design and operation. For example, a large dam with a deep storage reservoir and deep release point may discharge cool waters, while a dam with multiple release points may discharge mixed warm and cool waters. Stormwater management programs can also cause temperature changes by altering the volume and timing of stormwater delivery to waterbodies.

Increased or fluctuating temperatures can harm fish and other aquatic organisms whose life cycles and breeding success are inextricably linked to water temperature. Thermal modification has eliminated many fish species and other aquatic organisms from streams across the nation.

What Can Be Done to Address These Problems?

The threats discussed in this section impair a significant percentage of the nation's watersheds. What can be done to address these problems?

Water resource management has traditionally focused on specific sources of pollution such as sewage discharges, certain chemical pollutants such as dioxins or heavy metals, or narrowly defined water resources such as a river segment or wetland. While these approaches have successfully addressed many specific problems and should receive continued support, they often fail to address widespread problems that degrade watersheds.

In the past decade, many water resource practitioners have increased emphasis on watershed approaches to address land and water resource problems. They have considered the human activities that generate threats to watershed health. These practitioners have tried to integrate appropriate scientific, programmatic, and political perspectives to remedy these problems. The next section of this report describes progress of these watershed approaches.